

## QUANTUM-NOISE-LIMITED CAVITY RING-DOWN SPECTROSCOPY IN THE MID-INFRARED

ADAM J. FLEISHER, DAVID A. LONG, QINGNAN LIU, JOSEPH HODGES, *Material Measurement Laboratory, National Institute of Standards and Technology, Gaithersburg, MD, USA.*

We report a highly sensitive mid-infrared spectrometer capable of recording cavity ring-down events in the quantum (shot) noise limit. A linear optical cavity of finesse 31,000 was pumped by a distributed feedback quantum cascade laser (DFB-QCL) operating at  $4.5 \mu\text{m}$  until a cavity transmission threshold was reached. A fast optical switch then extinguished optical pumping and initiated a cavity decay which exhibited root-mean-square noise proportional to the square root of optical power (quantum noise) for several cavity time constants until a detector noise floor was reached. This spectrometer has achieved a noise-equivalent absorption of  $\text{NEA} = 2.6 \times 10^{-11} \text{ cm}^{-1}\text{Hz}^{-1/2}$  and a minimum absorption coefficient of  $\alpha = 2.3 \times 10^{-11} \text{ cm}^{-1}$  in 3 seconds. Applications for such a highly sensitive spectrometer operating in the mid-infrared region, including ultra-trace molecular spectroscopy of  $\text{CO}_2$  isotopologues and the direct interrogation of weak mirror birefringence and polarization-dependent losses, will be discussed.